Development of a Vibration and Shock Sensor Using Piezoelectric Ceramics

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When buildings are exposed to vibration or shock, those buildings can be damaged partially or fully depending on the energy of vibration. Hence, quantitative analysis of building vibration has become popular among researchers. In this research, a vibration sensor was developed using a piezoelectric ceramic cantilever beam and a tip mass to confirm that the vibration frequency of the building does not exceed the cosmetic damage range.

As the first step, a mathematical model was developed to calculate the resonance frequency of the cantilever beam with a tip mass. At the resonance frequency, maximum amplitude could be achieved resulting in a higher output voltage of the piezoelectric sensor. The developed mathematical model and finite element analysis were used to determine the accurate dimensions of the cantilever beam based piezoelectric sensor. According to the calculations, width, length and thickness of the piezoelectric material, copper beam and tip mass are 10x20x1, 10x100x0.3 and 10x30x3 mm respectively. Hence, the piezoelectric sensor output voltage was calculated using finite element analysis at the vibration frequency range that corresponds to the cosmetic damage. According to the calculations, threshold voltage level and frequency of the sensor to activate the alarm were 4.35 mv and 9.5 Hz respectively.

Arduino software was used to analyze the output signal of the sensor. Vibration source was used to verify the calculation steps. Finally, liquid crystal display and small buzzer were added to show the frequency and give a warning when vibration frequency exceeds the required level.

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